

We claim:

1. An apparatus for reducing the width of a plurality of slots or other openings spaced circumferentially around a slotted tubular member comprising:

(a) a seaming roller positioned to contact the outer surface of the slotted tubular member for transverse movement relative to the longitudinal axis of the slotted tubular member, and adapted to apply a force onto the slotted tubular member so as to reduce the slot width;

(b) a first detector adjacent the seaming roller for detecting an initial width of the plurality of slots and generating a detection signal proportional to the detected initial width;

(c) a comparator connected to the first detector for comparing the detected initial width to a set value indicative of a desired end slot width and to generating a correction signal proportional to the difference;

(d) an adjustor connected to the seaming roller and the comparator, for adjusting the force applied by the seaming roller to the plurality of slots in response to the correction signal.

2. The apparatus of claim 1, further comprising longitudinally feeding and axially rotating the slotted tubular member through the seaming roller.

3. The apparatus of claim 2, wherein the adjustor includes a hydraulic cylinder to apply the force to the seaming roller.

4. The apparatus of claim 2, wherein the adjustor includes a pneumatic cylinder to apply the force to the seaming roller.

5. The apparatus of claim 3, wherein the slotted tubular member is formed with a plurality of longitudinal slots and wherein the force applied by the seaming roller as the seaming roller moves across each of the plurality of slots is maintained with an accumulator attached to the hydraulic cylinder.

6. The apparatus of claim 5, further comprising a plurality of seaming rollers located circumferentially around the slotted tubular member.

7. The apparatus of claim 6, further comprising clamps adjacent to the seaming roller for clamping the slotted tubular member so as to hold the slotted tubular member centered relative to its longitudinal axis as it moves through the seaming roller.

8. The apparatus of claim 7, wherein the clamps includes diametrically opposed clamping rollers to clamp the tubular member, one of said clamping rollers being adapted to hold a fixed position and the other being adapted to apply a dampening clamping force to compensate for off centre movement of the slotted tubular member.

9. The apparatus of claim 5, which further comprises a second detector adapted to detect the final width of the plurality of slots, to generate a final width signal proportional to the detected final width; and wherein the comparator is adapted to compare the detected final width signal to a set value indicative of the desired end slot width.

10. The apparatus of claim 8, which further comprises a second detector adapted to detect the final width of the plurality of slots, to generate a final width signal proportional to the detected final width; and wherein the comparator is adapted to compare the detected final width signal to a set value indicative of the desired end slot width.

11. The apparatus of claim 8, wherein the clamping roller adapted to hold a fixed position, is connected to a tempsonic controlled hydraulic cylinder in order to apply a force to hold the fixed position.

12. The apparatus of claim 10, wherein the clamping roller adapted to hold a fixed position, is connected to a tempsonic controlled hydraulic cylinder in order to apply a force to hold the fixed position.

13. The apparatus of claim 11, wherein the clamping roller adapted to apply a dampening clamping force, is connected to a hydraulic cylinder and an accumulator in order to apply a dampened force.

14. The apparatus of claim 12, wherein the clamping roller adapted to apply a dampening clamping force, is connected to a hydraulic cylinder and an accumulator in order to apply a dampened force.

15. The apparatus of claim 14, wherein the clamping rollers are located transverse the longitudinal axis of the slotted tubular member.

16. The apparatus of claim 15, wherein the first or second detector uses optics to detect the width of the plurality of slots.

17. The apparatus of claim 16, wherein optics comprises a camera wherein the camera is

1 positioned to measure the slot width in pixels so as to generate a pixilated signal proportional to  
2 the width of the slot.

3 18. The apparatus of claim 15, wherein the first or second detector comprises a laser and a  
4 laser detector, the laser being positioned to direct a laser beam at the plurality of slots, and the  
5 laser detector being positioned to receive a reflected laser beam off the slotted tubular member  
6 and to generate a signal proportional to the reflected laser beam.

7 19. The apparatus of claim 18, wherein longitudinally feeding and axially rotating the slotted  
8 tubular member includes:

9 (a) a headstock housing;

10 (b) a chuck mounted on the headstock housing for receiving and securing the slotted tubular  
11 member; -

12 (c) a quill carried by the headstock housing for rotating the slotted tubular member once it is  
13 secured by the chuck; and

14 (d) a conveyor for conveying the headstock housing longitudinally relative to the seaming  
15 roller.

16 20. The apparatus of claim 19, wherein the headstock housing is mounted on a track for  
17 longitudinal movement relative to the seaming roller.

18 21. The apparatus of claim 20, wherein the comparator is a programmable logic controller  
19 that compares received signals with inputted stored set values.

20 22. The apparatus of claim 21, wherein the programmable logic controller receives inputted  
21 rates of longitudinal and axial movement for the slotted tubular member and provides output  
22 signals to directly control the conveyor, chuck and quill.

23 23. The apparatus of claim 1 further comprising moving the seaming roller and the clamps  
24 longitudinally along the slotted tubular member; and axially rotating the slotted tubular member  
25 through the seaming roller.

26 24. The apparatus of claim 1, wherein the slotted tubular member is metal.

27 25. The apparatus of claim 23, wherein the slotted tubular member is metal.

28 26. A method of reducing the width of a plurality of longitudinal slots or other openings  
29 spaced circumferentially around a slotted tubular member, comprising:

- (a) providing at least one seaming roller positioned to contact the outer surface of the slotted tubular member for transverse movement across the plurality of slots;
  - (b) detecting an initial width of each of the plurality of slots to generate a detection signal proportional to the detected initial dimensions;
  - (c) comparing the detected initial width of the slots to a set value indicative of a desired end slot width to generate a correction signal proportional to the difference;
  - (d) applying a downward force onto the slotted tubular member with the at least one seaming roller; and
  - (e) varying the force applied by the at least one seaming roller to the plurality of slots along the slotted tubular member in response to the correction signal.
27. The method of claim 26, further comprising longitudinally feeding and axially rotating the slotted tubular member through the at least one seaming roller.
28. The method of claim 27, further comprising maintaining the force applied by the at least one seaming roller as the seaming roller moves across each of the plurality of slots with an accumulator.
29. The method of claim 28, further comprising clamping the slotted tubular member so as to hold the slotted tubular member centered and to dampen harmonic vibrations as the slotted tubular member moves through the seaming roller.
30. The method of claim 29, further comprising detecting the final width of each of the plurality of slots, generating a final width signal proportional to the detected final width, and comparing the final width signal to the set value indicative of the desired end slot width.
31. The method of claim 30, further comprising moving the at least one seaming roller longitudinally along the length of the slotted tubular member.
32. The method of claim 26, further comprising moving the at least one seaming roller longitudinally along the length of the slotted tubular member.
33. A method of reducing the width of a plurality of longitudinal slots or other openings spaced circumferentially around a slotted tubular member, comprising:
- (a) providing at least one seaming roller positioned to contact the outer surface of the slotted tubular member for transverse movement across the plurality of slots;

(b) applying a downward force onto the slotted tubular member with the at least one seaming roller; and

(c) maintaining the force applied by the at least one seaming roller as the seaming roller moves across each of the plurality of slots with an accumulator.

34. A method of reducing the width of a plurality of longitudinal slots or other openings spaced circumferentially around a slotted tubular member, comprising:

(a) providing at least one seaming roller positioned to contact the outer surface of the slotted tubular member for transverse movement across the plurality of slots;

(b) applying a downward force onto the slotted tubular member with the at least one seaming roller; and

(c) longitudinally feeding and axially rotating the slotted tubular member through the at least one seaming roller.

35. A method of forming a slotted tubular member having a plurality of longitudinal slots comprising:

(a) providing at least one seaming roller positioned to contact the outer surface of the slotted tubular member for transverse movement across the plurality of slots;

(b) detecting a width of each of the plurality of slots to generate a detection signal proportional to the detected width;

(c) comparing the detected width of the slots to a set value indicative of a desired end slot width to generate a correction signal proportional to the difference;

(d) applying a downward force onto the slotted tubular member with the at least one seaming roller; and

(e) varying the force applied by the at least one seaming roller to the plurality of slots along the slotted tubular member in response to the correction signal so that each opening has a profile with a width tolerance, that throughout the length of the slot profile, varies no more than +/- 0.0381 mm from the desired end slot width.

36. The method of claim 35, further comprising detecting the final width of each of the plurality of slots, generating a final width signal proportional to the detected final width, and comparing the final width signal to the set value indicative of the desired end slot width.

37. The method of claim 36, further comprising varying the force applied by the at least one seaming roller to the plurality of slots along the slotted tubular member in response to a final correction signal proportional to the difference between the final width signal and the set value indicative of the desired end slot width.

38. An apparatus for reducing the width of a plurality of longitudinal slots or other openings spaced circumferentially around a slotted tubular member comprising:

(a) a seaming roller positioned to contact the outer surface of the slotted tubular member for transverse movement across the plurality of slots, and adapted to apply a force onto the slotted tubular member so as to reduce the slot width;

(b) first detector adjacent the seaming roller for detecting a width of the plurality of slots and generating a detection signal proportional to the detected width;

(c) a comparator connected to the first detector for comparing the detected width to a set value indicative of a desired end slot width and to generating a correction signal proportional to the difference;

(d) an adjustor connected to the seaming roller and the comparator, for adjusting the force applied by the seaming roller to the plurality of slots in response to the correction signal.

39. A method of reducing the width of a plurality of longitudinal slots or other openings spaced circumferentially around a slotted tubular member, comprising:

(a) providing at least one seaming roller positioned to contact the outer surface of the slotted tubular member for transverse movement across the plurality of slots;

(b) detecting a width of each of the plurality of slots to generate a detection signal proportional to the detected width;

(c) comparing the detected width of the slots to a set value indicative of a desired end slot width to generate a correction signal proportional to the difference;

(d) applying a downward force onto the slotted tubular member with the at least one seaming roller; and

(e) varying the force applied by the at least one seaming roller to the plurality of slots along the slotted tubular member in response to the correction signal.

40. A method of forming a slotted tubular member having a plurality of longitudinal slots

1 comprising:

2 (a) providing at least one seaming roller positioned to contact the outer surface of the  
3 slotted tubular member for transverse movement across the plurality of slots;

4 (b) detecting a width of each of the plurality of slots to generate a detection signal  
5 proportional to the detected width;

6 (c) comparing the detected width of the slots to a set value indicative of a desired end slot  
7 width to generate a correction signal proportional to the difference;

8 (d) applying a downward force onto the slotted tubular member with the at least one seaming  
9 roller; and

10 (e) varying the force applied by the at least one seaming roller to the plurality of slots along  
11 the slotted tubular member in response to the correction signal so that each opening has a profile  
12 with a width tolerance, that throughout the length of the slot profile, varies no more than +/-  
13 0.0127 mm from the desired end slot width.

14 41. A method of forming a slotted tubular member having a plurality of longitudinal slots  
15 comprising:

16 (a) providing at least one seaming roller positioned to contact the outer surface of the  
17 slotted tubular member for transverse movement across the plurality of slots;

18 (b) detecting a width of each of the plurality of slots to generate a detection signal  
19 proportional to the detected width;

20 (c) comparing the detected width of the slots to a set value indicative of a desired end slot  
21 width to generate a correction signal proportional to the difference;

22 (d) applying a downward force onto the slotted tubular member with the at least one  
23 seaming roller; and

24 (e) varying the force applied by the at least one seaming roller to the plurality of slots along  
25 the slotted tubular member in response to the correction signal so that each opening has a profile  
26 with a width tolerance, that throughout the length of the slot profile, varies no more than +/-  
27 0.00762 mm from the desired end slot width.

28 42. A slotted tubular liner comprising:

29 a metal slotted tubular member formed with a plurality of longitudinal slots  $\leq 3.175\text{mm}$  in

1 width spaced circumferentially around the member, each slot having been cut and then  
2 transversely seamed to have a profile with a width tolerance, that throughout the length of the  
3 slot profile, varies no more than  $\pm 0.0127$  mm from a desired end slot width.  
4 43. The metal slotted tubular member of claim 42, wherein each slot is transversely seamed  
5 to have a profile with a width tolerance, that throughout the length of the slot profile, varies no  
6 more than  $\pm 0.00762$  mm from a desired end slot width.